P8 SPACE PHYSICS
Question Practice

Name: ________________________
Class: ________________________
Date: ________________________

Time: 140 minutes
Marks: 140 marks
Comments: GCSE PHYSICS ONLY
In 1929, the astronomer Edwin Hubble observed that the light from galaxies moving away from the Earth had longer wavelengths than expected.

(a) What name is given to this effect?

___________________________________________________________________
___________________________________________________________________

(b) From his observations, Hubble was able to calculate the speed of a galaxy and the distance of the galaxy from the Earth.

Figure 1 shows the results of Hubble’s calculations.

Figure 1

What relationship between the speed of a galaxy and the distance is suggested by Hubble’s results?

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___________________________________________________________________

(1)
The observations made by Hubble support the idea that the Universe is expanding. This means that galaxies are continually moving away from each other and from the Earth.

**Figure 2** shows a student using a balloon to model the idea of an expanding Universe.

Some dots, which represent galaxies, were marked on the balloon. The balloon was then inflated.

**Figure 2**

(c) Give one strength and one weakness of this model in representing the idea of an expanding Universe.

Strength

___________________________________________________________________

Weakness

___________________________________________________________________

(2)

In the 1950s there were two main theories to explain how the Universe began.

**Theory 1**

The Universe has always existed, it is continually expanding. New galaxies are formed as older galaxies die out.

**Theory 2**

The Universe began from a very small region that was extremely hot and dense. The Universe has been expanding ever since.

(d) In what way do the observations made by Hubble support both Theory 1 and Theory 2?

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(1)
Most scientists now believe that Theory 2 is correct.
Suggest what is likely to have caused scientists to start thinking Theory 1 is wrong.

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___________________________________________________________________

(1)

The early Universe contained only the lightest element.

(a) Use the correct answer from the box to complete the sentence.

hydrogen  iron  uranium

The early Universe contained only _______________________ .

(1)

(b) Use the correct answer from the box to complete the sentence.

main sequence star  protostar  supernova

The heaviest elements are formed only in a ________________________ .

(1)

(c) Use the correct answer from the box to complete the sentence.

red giant  red super giant  white dwarf

Only a star much bigger than the Sun can become a __________________ .

(1)
(d) The Universe now contains a large variety of different elements.

Describe how this happened.

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(4)
(Total 7 marks)
Scientists can use the visible light spectrum from distant stars to determine whether the stars are moving.

The visible light spectrum from stars includes dark lines at specific wavelengths.

(a) The diagram shows the visible light spectrum from the Sun and from four other stars, A, B, C and D.

(i) Which star, A, B, C or D, is moving away from the Earth?

(ii) How does the speed of star B compare with the speed of star D?

Tick (✓) one box.

<table>
<thead>
<tr>
<th>The speed of star B is greater than the speed of star D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>The speed of star B is less than the speed of star D.</td>
</tr>
<tr>
<td>The speed of star B is the same as the speed of star D.</td>
</tr>
</tbody>
</table>

(1)
(b) A radio wave is emitted by a star. The radio wave has a wavelength of 1500 m and a frequency of 200 000 Hz.

Calculate the speed of this radio wave.

Choose the correct unit from the list below.

\[
\begin{array}{ccc}
\text{m} & \text{m/s} & \text{m/s}^2 \\
\hline
\text{m/s} & \text{m/s} & \text{m/s}^2 \\
\text{m/s} & \text{m/s} & \text{m/s}^2 \\
\text{m/s} & \text{m/s} & \text{m/s}^2
\end{array}
\]

Speed = __________________________ unit __________________

(Total 5 marks)

A teacher demonstrates the production of circular waves in a ripple tank.

Diagram 1 shows the waves at an instant in time.

Diagram 1

(a) Show on Diagram 1 the wavelength of the waves.

(1)
(b) The teacher moves the source of the waves across the ripple tank.

Diagram 2 shows the waves at an instant in time.

Diagram 2
(Actual size)

(i) Use the correct answer from the box to complete each sentence.

| decreased | increased | stayed the same |

In Diagram 2, the observed wavelength of the waves at X has ________________.

In Diagram 2, the frequency of the waves at X has ________________.

(ii) Take measurements from Diagram 2 to determine the wavelength of the waves received at X.

Give the unit.

__________________________________________________________________________________

__________________________________________________________________________________

Wavelength = ____________________

(3)
The teacher uses the waves in the ripple tank to model the changes in the wavelengths of light observed from distant galaxies.

When observed from the Earth, there is an increase in the wavelength of light from distant galaxies.

(i) State the name of this effect.

(ii) What does this increase in wavelength tell us about the movement of most galaxies?

(iii) Explain how this observation supports the Big Bang theory of the formation of the Universe.

(iv) State one other piece of evidence that supports the Big Bang theory of the formation of the Universe.

(Total 13 marks)
Man-made satellites can orbit the Earth, as shown in the figure below.

The satellite experiences a resultant force directed towards the centre of the orbit.

The resultant force is called the centripetal force

(a) What provides the centripetal force on the satellite?

___________________________________________________________________  (1)

(b) State two factors that determine the size of the centripetal force on the satellite.

1. _________________________________________________________________  
2. _________________________________________________________________  (2)
The table below gives data for five different satellites orbiting the Earth.

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Average height above Earth’s surface in kilometres</th>
<th>Time taken to orbit Earth once in minutes</th>
<th>Mass of satellite in kilograms</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>370</td>
<td>93</td>
<td>419 000</td>
</tr>
<tr>
<td>B</td>
<td>697</td>
<td>99</td>
<td>280</td>
</tr>
<tr>
<td>C</td>
<td>827</td>
<td>103</td>
<td>630</td>
</tr>
<tr>
<td>D</td>
<td>5 900</td>
<td>228</td>
<td>400</td>
</tr>
<tr>
<td>E</td>
<td>35 800</td>
<td>1440</td>
<td>2 030</td>
</tr>
</tbody>
</table>

(i) State the relationship, if any, between the height of the satellite above the Earth’s surface and the time taken for the satellite to orbit the Earth once.

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........................................................................................................................................

(1)

(ii) State the relationship, if any, between the time taken for the satellite to orbit the Earth once and the satellite’s mass.

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(1)

(d) Over 300 years ago, the famous scientist Isaac Newton proposed, with a ‘thought experiment’, the idea of satellites.

Newton suggested that if an object was fired at the right speed from the top of a high mountain, it would circle the Earth.

Why did many people accept Isaac Newton’s idea as being possible?

Tick (√) one box.

Isaac Newton was a respected scientist who had made new discoveries before. 

Isaac Newton went to university.

It was a new idea that nobody else had thought of before.

(1)

(Total 6 marks)
Stars go through a life cycle. About 90% of all stars are in the ‘main sequence’ period of the life cycle.

(a) Stars are stable during the ‘main sequence’ period of the life cycle.

Why?

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___________________________________________________________________

(b) The table gives an estimated time for the number of years that three stars, X, Y and Z, will be in the ‘main sequence’ period of their life cycle.

<table>
<thead>
<tr>
<th>Star</th>
<th>Relative mass of the star compared to the Sun</th>
<th>Estimated ‘main sequence’ period in millions of years</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>0.1</td>
<td>4 000 000</td>
</tr>
<tr>
<td>Y</td>
<td>1.0</td>
<td>9 000</td>
</tr>
<tr>
<td>Z</td>
<td>40.0</td>
<td>200</td>
</tr>
</tbody>
</table>

(i) This data suggests that there is a pattern linking the mass of a star and the number of years the star is in the ‘main sequence’ period of its life cycle.

What is the pattern suggested by the data?

___________________________________________________________________
___________________________________________________________________

(ii) Scientists cannot give the exact number of years a star will be in the ‘main sequence’ period.

Suggest why.

___________________________________________________________________
___________________________________________________________________

___________________________________________________________________

(1)
Nuclear fusion is the process by which energy is released in stars.

Which one of the following can be concluded from the data in the table?

Draw a ring around the correct answer in the box to complete the sentence.

The rate of nuclear fusion in a large star is faster than, the same as, or slower than in a small star.

Explain the reason for your answer.

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(c) In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.

Describe what happens to a star much bigger than the Sun, once the star reaches the end of the ‘main sequence’ period of its life cycle.

Your answer should include the names of the stages the star passes through.

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(6) (Total 12 marks)
The ‘big bang’ theory is one theory explaining the origin of the Universe.

(a) The graphs X, Y and Z, show how the size of the Universe may have changed with time.

Which graph would the ‘big bang’ theory suggest is correct?

Write your answer, X, Y or Z, in the box.

Explain the reason for your answer.

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(b) In 1948, an alternative to the ‘big bang’ theory, called the ‘steady state’ theory, was developed.

The ‘steady state’ theory suggested that the Universe, although expanding, has always existed without a beginning in time.

(i) Complete the following sentence by drawing a ring around the correct line in the box.

The measurement of red-shift in the light from distant galaxies provides evidence to support

- only the ‘big bang’ theory.
- only the ‘steady state’ theory.
- both the ‘big bang’ and ‘steady state’ theories.
In 1965, scientists rejected the ‘steady state’ theory in favour of the ‘big bang’ theory.

Suggest what might cause scientists to stop supporting one theory and to start supporting an alternative theory.

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(Total 5 marks)

Objects moving in a circle experience a force called **centripetal** force, which acts to the centre of the circle.

The diagram shows the apparatus used by two students to find out how the centripetal force acting on an object affects the speed of the object.

(a) (i) In which direction does the centripetal force act on the rubber bung?

__________________________________________________________________________________________________________

(1)

(ii) In this investigation, what provides the centripetal force?

__________________________________________________________________________________________________________

__________________________________________________________________________________________________________

(1)
(b) One student swung the rubber bung around in a circle at constant speed. The second student timed how long it took the rubber bung to complete 10 rotations. The students then calculated the speed of the rubber bung, using the radius of the circle and the time to complete one rotation. The students repeated this for several different values of centripetal force.

(i) During the investigation, the radius of the circle and the mass of the rubber bung were not changed.

Explain why.

______________________________________________________________
______________________________________________________________
______________________________________________________________
______________________________________________________________

(ii) One of the variables in this investigation was the time taken by the rubber bung to complete 10 rotations.

Which two words can be used to describe this variable?

Draw a ring around each of your two answers.

- continuous
- control
- dependent
- independent

(iii) The students timed 10 rotations of the rubber bung, rather than just one rotation.

Suggest why.

______________________________________________________________
______________________________________________________________
There is a relationship between the speed of an object moving in a circle and the centripetal force acting on the object.

What conclusion about this relationship can the students make from their data?
(d) The diagram shows a satellite in a circular orbit above the Earth. The satellite is part of the global positioning system (GPS). The satellite orbits the Earth **twice** every 24 hours.

![Diagram of a satellite in orbit around the Earth]

(i) What provides the centripetal force needed to keep the satellite in its orbit around the Earth?

______________________________________________________________

(1)

(ii) Is this satellite in a geostationary orbit?

Draw a ring around your answer. **Yes** **No**

Give a reason for your answer.

______________________________________________________________

______________________________________________________________

(1)

(Total 9 marks)

(a) Brown dwarf stars are thought to have been formed in the same way as other stars. They are too small for nuclear fusion reactions to take place in them. Brown dwarf stars emit infrared radiation but are not hot enough to emit visible light.

(i) Describe how a star is formed.

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(2)
(ii) Describe the process of nuclear fusion.

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(iii) Scientists predicted that brown dwarf stars existed before the first one was discovered in 1995.

Suggest one reason why scientists are now able to observe and identify brown dwarf stars.

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(b) In the 18th century some scientists suggested a theory about how the planets formed in the Solar System. The theory was that after the Sun formed, there were cool discs of matter rotating around the Sun. These cool discs of matter formed the planets. The scientists thought this must have happened around other stars too.

(i) Thinking about this theory, what would the scientists have predicted to have been formed in other parts of the Universe?

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________________________________________________________________________


(ii) Since the 1980s scientists studying young stars have shown the stars to be surrounded by cool discs of rotating matter.

What was the importance of these observations to the theory the scientists suggested in the 18th century?

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________________________________________________________________________


(1)
(c) The Earth contains elements heavier than iron.

Why is the presence of elements heavier than iron in the Earth evidence that the Solar System was formed from material produced after a massive star exploded?

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(Total 7 marks)

(a) Observation of the spectra from distant galaxies provides evidence to support the ‘Big Bang’ theory.

(i) Complete the following sentence.

Many scientists think that the ‘Big Bang’ theory describes the __________________________

______________________________________________________________________________

(1)

(ii) Tick (✓) one box to complete the sentence.

The discovery of cosmic microwave background radiation was important

because it ...

proved the ‘Big Bang’ theory to be correct. 

(provided more evidence to support the ‘Big Bang’ theory. 

proved the Universe will continue to expand forever.

(1)
(b) Many stars are part of a binary star system. Binary star systems have two stars.

The visible spectrum from stars includes dark lines. These lines are at specific wavelengths.

The diagram shows the position of two dark lines in the spectrum from the Sun. It also shows the same lines in the spectra from two stars A and B in a binary star system at the same point in time.

(i) What name is given to the effect shown in the spectrum from star A?

__________________________________________________________________________________________

(1)
Scientists have concluded that the two stars in a binary star system orbit around a fixed point between the two stars.

A comparison of the spectra from the two stars in a binary star system provides evidence to support this conclusion.

Explain how.

Galaxies emit all types of electromagnetic wave.

(a) (i) Which type of electromagnetic wave has the shortest wavelength?

(ii) State one difference between an ultraviolet wave and a visible light wave.

(b) Electromagnetic waves travel through space at a speed of \(3.0 \times 10^8\) m/s.

The radio waves emitted from a distant galaxy have a wavelength of 25 metres.

Calculate the frequency of the radio waves emitted from the galaxy and give the unit.

\[
\text{Frequency} = \frac{\text{Speed}}{\text{Wavelength}} = \frac{3.0 \times 10^8}{25} = 1.2 \times 10^7 \text{ Hz}
\]
Scientists use a radio telescope to measure the wavelength of the radio waves emitted from the galaxy in part (b) as the waves reach the Earth. The scientists measure the wavelength as 25.2 metres. The effect causing this observed increase in wavelength is called red-shift.

(i) The waves emitted from most galaxies show red-shift.

What does red-shift tell scientists about the direction most galaxies are moving?

________________________________________________________________________
________________________________________________________________________

(ii) The size of the red-shift is not the same for all galaxies.

What information can scientists find out about a galaxy when they measure the size of the red-shift the galaxy produces?

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(iii) What does the observation of red-shift suggest is happening to the Universe?

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(Total 9 marks)
Immediately after the ‘big bang’, at the start of the Universe, there were only atoms of the element hydrogen (H).

Now there are over one hundred elements. Scientists think that all the elements on Earth are also present throughout the Universe.

(a) Explain how atoms of the element (He) are formed in a star.

(b) Explain how atoms of very heavy elements, such as gold (Au), were formed.

(c) Scientists have only examined a tiny fraction of the Universe.

What is the basis for scientists thinking that the elements found on Earth are present throughout the Universe?

(Total 5 marks)
(a) The ‘Big Bang’ theory uses red-shift as evidence to explain the beginning of the Universe. How does the red-shift from distant galaxies provide evidence for the beginning of the Universe?

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(3)

(b) Cosmic microwave background radiation (CMBR) is a type of electromagnetic radiation. CMBR fills the Universe. It was first discovered in 1965 by two astronomers called Penzias and Wilson.

(i) What do scientists believe is the origin of CMBR?

___________________________________________________________________
___________________________________________________________________

(1)

(ii) Why was the discovery of CMBR so important to the scientists believing the ‘Big Bang’ theory to be correct?

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___________________________________________________________________

(1)

(iii) How is the wavelength of CMBR likely to change, if at all, over the next billion years? Give a reason for your answer.

___________________________________________________________________
___________________________________________________________________

(2)
(a) As part of its life cycle, a star changes from being a protostar to a main sequence star. Explain the difference between a protostar and a main sequence star.
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___________________________________________________________________
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(2)

(b) The early Universe contained only atoms of hydrogen. The Universe now contains atoms of over one hundred different elements. Explain how the different elements now contained in the Universe were formed.
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(3)

Optical telescopes may be used to observe galaxies. Some optical telescopes are on the Earth and some are on satellites in space. Scientists have observed that the wavelengths of the light from galaxies moving away from the Earth are longer than expected. This observation is called red-shift.

(i) What does the size of the red-shift tell the scientists about the distance a galaxy is from the Earth?
___________________________________________________________________
___________________________________________________________________

(1)

(ii) Complete the following passage.
Red-shift provides evidence to support the ‘big bang’ theory. The ‘big bang’ theory is one of the ways of explaining the ____________________ of the Universe.

(1)

(Total 2 marks)
The diagram, drawn below, places stars in one of four groups. Where a star is placed on the diagram is determined by the surface temperature and relative luminosity of the star. A star with a relative luminosity of 1, emits the same amount of energy every second as the Sun.

(a) The Sun will spend most of its life cycle as a main sequence star. This is the stable period of the Sun’s life cycle.

What happens to cause the stable period in the life cycle of a star to end?

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___________________________________________________________________

(1)
The 'Big Bang' theory is one theory of the origin of the Universe.

(a) (i) Explain what is meant by the 'Big Bang' theory.

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___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
(2)

(ii) The light arriving from distant galaxies provides scientists with evidence to support the 'Big Bang' theory.

Explain how.
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___________________________________________________________________
___________________________________________________________________
___________________________________________________________________
(2)

(b) Use the information in the diagram to describe what will happen to the Sun after the stable period ends.
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(2)
At a meeting held in 2005, a group of scientists claimed that new data had been collected that showed the ‘Big Bang’ theory to be wrong. Other scientists said that there was no reason to doubt the ‘Big Bang’ theory.

What should scientists do when a theory does not appear to be supported by new data?

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Scientists can answer many questions about the Universe, but not the question:

**Why was the Universe created?**

Suggest a reason why this question cannot be answered by scientists.

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Our star, the Sun, is stable.

Explain what the conditions need to be for a star to remain stable.

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(Total 7 marks)
(b) Shortly after the ‘big bang’, hydrogen was the only element in the Universe.

Explain how the other elements came to be formed.

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(3) (Total 5 marks)

(a) In 1929, the astronomer Edwin Hubble observed that the light from galaxies that are moving away from the Earth showed a red-shift.

What is red-shift?

___________________________________________________________________
___________________________________________________________________

(1)
(b) By measuring the *red-shift*, Hubble was able to calculate the speed at which the galaxies are moving away from the Earth. He was also able to calculate the distance of these galaxies from the Earth.

The graph shows some of the data calculated by Hubble.

(i) The data from two galaxies, \(M\) and \(N\), has been included in the graph. The light from galaxy \(M\) has a smaller *red-shift* than the light from galaxy \(N\).

What does the difference in *red-shift* tell scientists about the two galaxies, \(M\) and \(N\)?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
(ii) The gradient of the line drawn on the graph gives a number known as the Hubble constant. The Hubble constant can be used to estimate when the universe began.

Use the graph to calculate the value of the Hubble constant.

Show clearly how you obtained your answer.

Hubble constant = ______________________ km/s per megaparsec
More recently, data has been obtained from more distant galaxies. The results from the more recent data give a totally different value for the Hubble constant to the one calculated from the 1929 data.

Which set of data, the 1929 or the more recent, is most likely to give the value closest to the true value for the Hubble constant?

Draw a ring around your answer.

1929 more recent

Give a reason for your answer.

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(1)
(c) The Andromeda galaxy is not moving away from the Earth. It is actually moving towards the Earth. This means that the light from Andromeda shows a blue-shift.

How do the wavelength and frequency of the light from Andromeda seem to have changed when viewed from the Earth?

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(2)
(Total 8 marks)

Every star goes through a ‘life cycle’.

(a) Describe how a star forms.

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___________________________________________________________________
___________________________________________________________________
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___________________________________________________________________
___________________________________________________________________

(2)

(b) During a long period of its life, a star remains in a stable state.

Explain why a star remains stable.

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___________________________________________________________________
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___________________________________________________________________

(2)
(c) Some stars are much more massive than the Sun.

Describe what will happen to a star, originally much more massive than the Sun, after it reaches its red giant stage.

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___________________________________________________________________
___________________________________________________________________
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(2)
(Total 6 marks)

Read this statement from a website.

Immediately after the ‘big bang’, at the start of the Universe, there were only atoms of the element hydrogen (H).
Now the Universe contains atoms of over one hundred elements.

(a) Explain how atoms of the element helium (He) are formed in a star.

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___________________________________________________________________
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___________________________________________________________________

(2)

(b) Explain how atoms of very heavy elements, such as gold (Au), were formed.

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(2)
(c) Explain how, and when, atoms of different elements may be distributed throughout the Universe.

___________________________________________________________________
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(2)
(Total 6 marks)
Mark schemes

1. (a) red–shift
   (b) the further away from the Earth, the faster a galaxy is moving
   (c) strength
   as the balloon expands the dots get further apart, representing the galaxies moving apart
   weakness
   dots are only on the surface of the balloon, galaxies are throughout the universe
   or
   there is a limit to how far the balloon can expand
   (d) both theories suggest that the Universe is expanding
   (e) new evidence / observations that cannot be explained by Theory 1
   accept specific example of new evidence ie CMBR

2. (a) hydrogen
   (b) supernova
   (c) red super giant
   (d) any four from:
   - fusion takes place within stars
   - hydrogen formed into helium
   - fusion continued and formed larger elements
   - elements heavier than iron were formed in supernova
   - (heavy) elements were scattered by the supernova explosion.
   accept light elements formed
(a) (i) C

(ii) The speed of star B is less than the speed of star D.

(b) 300 000 000

allow 1 mark for correct substitution ie 200 000 × 1500 provided no subsequent step shown

m / s

allow unit correctly indicated in list if not written in answer space

3

(a) wavelength correctly shown

4

(b) (i) increased

decreased

(ii) 17-18 inclusive

evidence of measurement divided by 3 or mean of 3 separate measurements

mm

accept cm if consistent with answer

(c) (i) red shift

(ii) moving away

(iii) the furthest galaxies show the biggest red shift

(meaning that) the furthest galaxies are moving fastest

(so the) Universe is expanding

(extrapolating backwards this suggests that) the Universe started from an initial point

4
(iv) cosmic microwave background radiation
    allow CMBR

(a) gravitational attraction (between the satellite and the Earth)
    allow gravity
    allow weight of the satellite

(b) any two from:
    • mass of satellite
    • speed / velocity (of satellite)
    • radius of orbit / circle
    allow height above the Earth
    radius / height alone is insufficient

(c) (i) increasing the height (above the Earth’s surface) increases the time (for one orbit)
    allow a positive correlation
    allow as one gets bigger, the other gets bigger, or vice versa
    ignore they are directly proportional

(ii) there is no relationship / correlation

(d) Isaac Newton was a respected scientist who had made new discoveries before

(a) forces (within the star) are balanced
    if specific forces are mentioned they must be appropriate

(b) (i) bigger the mass (of the star) the shorter the ‘main sequence’ period
    accept bigger the star the shorter the time
(ii) any one from:

- insufficient evidence
- do not know (exact) amount of hydrogen in star
  accept do not know (exact) mass of star
- time too long (to measure directly)
- may be other factors (not yet known) that determine length of ‘main sequence’ period
- values are based on theory / calculation

(iii) faster than

larger stars have a shorter ‘main sequence’ period so they must have the faster (rate of) nuclear fusion
	here must be a link between shorter ‘main sequence’ and nuclear fusion, this may be implied from the first marking point

the end of ‘main sequence’ happens as the hydrogen in (the core of) a star is used up

or

(since) they use up hydrogen at a faster (rate)

accept more massive stars (are brighter so) release energy faster
Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also refer to the information in the Marking guidance, and apply a ‘best-fit’ approach to the marking.

0 marks
No relevant content.

**Level 1 (1-2 marks)**
There is a basic description of what happens to a star much larger than the Sun after the ‘main sequence’ period.

OR

Two stages are correctly named and are in the correct sequence.

**Level 2 (3-4 marks)**
There is a clear description of what happens to a star much larger than the Sun after the ‘main sequence’ period.

AND

At least two stages are correctly named and are in the correct sequence.

**Level 3 (5-6 marks)**
There is a detailed description of what happens to a star much larger than the Sun after the ‘main sequence’ period.

AND

At least three stages are named, in the correct sequence. There are no additional incorrect stages given.

**Examples of the points made in the response:**

*extra information*

- (the core of the) star runs out of hydrogen
- (the star) expands (to form)
- (the star) cools (to form)
  - the core shrinks
  - helium starts to fuse to form other elements
- a red supergiant
  *accept super red giant*
  *do not accept red giant*
- (outer layers) explode
  - fusion of lighter elements to form heavier elements (up to iron)
- as a supernova
  - elements heavier than iron are formed
  *accept heaviest elements are formed*
  - core shrinks
- becoming a neutron star
if mass large enough (core collapses)

(to form) a black hole

if a correct description and sequence for a star the same size as the Sun and much bigger than the Sun given without clearly indicating which is which is limited to Level 2

(a) Y

accept cannot be X as size is increasing

shows Universe expanding

this scores if Y or Z is chosen

accept exploding outwards

from a (very small) point

this only scores if Y is chosen

accept from zero (size)

answers in terms of planets

negate the last two mark points

(b) (i) both the ‘big bang’ and ‘steady state’ theories

(ii) (new) evidence that supports / disproves a theory

accept proves for supports

or

(new) evidence not supported by current theory

accept there may be more evidence supporting one (theory) than the other (theory)

accept new evidence specific to this question eg measurement of CBR

or

some types of star only found in distant parts of Universe (steady state suggests should be same throughout Universe)

(a) (i) towards the centre of the circle

accept inwards

accept a correct description

‘along the string’ is insufficient
(ii) tension (in the string)
   accept pull of the string
   or
   weight (on the end of the string)
   ‘the string’ is insufficient
   ‘the student’ is insufficient
   ‘turning action’ is insufficient

(b) (i) each may (also) affect the speed
   accept results for speed

so only one independent variable
   accept only one variable affects dependent variable
   ‘fair test’ is insufficient
   ‘they are control variables’ is insufficient

(ii) continuous
    both required

dependent

(iii) reduces (absolute) timing error (for one rotation)
   accept too fast to time one
   or
   increases / improves reliability / accuracy (for one rotation)
   ignore checking for anomalous results
   to work out an average is insufficient

(c) speed increases with centripetal force
   accept positive correlation
   do not accept proportional

(d) (i) gravitational pull (of the Earth)
   accept gravity

(ii) No
   both parts required – however this may have been subsumed within
   the reason
   geostationary orbits once every 24 hours
   accept a correct comparative description

[9]
(a) (i) (enough) dust and gas (from space) is pulled together
    accept nebula for dust and gas
    accept hydrogen for gas
    accept gas on its own
    dust on its own is insufficient
    mention of air negates this mark

    by:
    gravitational attraction
    or
    gravitational forces
    or
    gravity

    ignore any (correct) stages beyond this

(ii) joining of two (atomic) nuclei (to form a larger one)
    do not accept atoms for nuclei

(iii) more sensitive astronomical instruments / telescopes
    or
    infrared telescopes developed
    accept better technology
    more knowledge is insufficient

(b) (i) (other) planets / solar systems
    do not accept galaxy
    moons is insufficient

(ii) provided evidence to support theory
    accept proves the theory

(c) elements heavier than iron are formed only when a (massive) star explodes
    accept materials for elements
    accept supernova for star explodes
    accept stars can only fuse elements up to (and including) iron

(a) (i) origin of the Universe
    accept (why) the Universe is expanding
    do not accept origin of the Earth

(ii) provided more evidence to support the ‘Big Bang’ theory
(b) (i) red-shift
   
   accept Doppler (shift)

(ii) (at the point in time shown the observed spectrum from) star A (shows it) is moving away from the Earth
   
   accept star A is moving away
   star A shows red-shift is insufficient

   light from star B shows a decrease in wavelength
   
   accept light from star B shows blue-shift
   accept light from star B shows an increase in frequency

   so star B is moving towards Earth

(a) (i) gamma
   
   accept correct symbol

(ii) any one from:

   • (ultraviolet has a) higher frequency
     ultraviolet cannot be seen is insufficient

   • (ultraviolet has a) greater energy

   • (ultraviolet has a) shorter wavelength
     ignore ultraviolet causes cancer etc

(b) 1.2 × 10^7 / 12 000 000
   
   allow 1 mark for correct substitution, ie 3 × 10^8 = f × 25

   hertz / Hz / kHz / MHz
   
   do not accept hz or HZ
   answers 12 000 kHz or 12 MHz gain 3 marks
   for full credit the numerical answer and unit must be consistent

(c) (i) away (from each other)
   
   accept away (from the Earth)
   accept receding

(ii) distance (from the Earth)
   
   accept how far away (it is)
speed galaxy is moving

(iii) (Universe is) expanding

(a) fusion

\textit{do not credit any response which looks like ‘fission’}

of hydrogen / H (atoms)

\textit{credit only if 1st mark point scores}

(b) fusion of other / lighter atoms / elements

\textit{reference to big bang nullifies both marks}

during supernova / explosion of star(s)

(c) the (available) evidence: supports this idea

\textbf{or}

does not contradict this idea

\textbf{or}

can be extrapolated to this idea

\textbf{or}

(electromagnetic) spectrum from other stars is similar to sun

\textbf{[5]}

(a) any \textbf{three} from:

- red-shift shows galaxies are moving away (from each other / the Earth)
- more distant galaxies show bigger red-shift

\textbf{or}

more distant galaxies show a greater increase in wavelength

\textit{accept correct reference to frequency in place of wavelength}

- (in all directions) more distant galaxies are moving away faster

\textit{accept (suggests) universe is expanding}

- suggests single point of origin (of the universe)

\textbf{[3]}

(b) (i) (radiation produced shortly after) ‘Big Bang’

\textit{accept beginning of time / beginning of the universe for ‘Big Bang’}

\textbf{[1]}
(ii) any one from:

- can only be explained by ‘Big Bang’
- existence predicted by ‘Big Bang’
- provides (further) evidence for ‘Big Bang’
  
  * ignore proves ‘Big Bang’ (theory)
  * ignore reference to red-shift

(iii) increase

  accept becomes radio waves

  universe continues to accelerate outwards
  
  accept as universe continues to expand

  or

  greater red-shift

(a) a protostar is at a lower temperature

  or

  a protostar does not emit radiation /energy

  as (nuclear) fusion reactions have not started
  
  accept heat or light for energy

(b) by (nuclear) fusion

  accept nuclei fuse (together)

  nuclear fusion and fission negates this mark

  of hydrogen to helium

  elements heavier than iron are formed in a supernova

  accept a specific example e.g. heavier elements such as gold are formed in a supernova

  accept heavier elements (up to iron) formed in red giant/red super giant

  reference to burning (hydrogen) negates the first 2 marks
(i) bigger the red-shift, further the galaxy is from the Earth
   accept red-shift and distance are directly proportional
   accept there is a positive correlation

(ii) origin / start / beginning / creation
    accept expansion

(a) runs out of hydrogen (in its core)
   accept nuclear fusion slows down
   do not accept fuel for hydrogen
   do not accept nuclear fusion stops
   ignore reference to radiation pressure / unbalanced forces

(b) temperature decreases / (relative) luminosity increases as it changes to a red giant
    if both temperature and luminosity are given both must be correct

   temperature increases / (relative) luminosity decreases as it changes to a white dwarf
    if both temperature and luminosity are given both must be correct

   correct change in temperature and (relative) luminosity as Sun changes to a red giant and then to a white dwarf
   an answer changes to a red giant and then white dwarf with no mention or an incorrect mention of temperature or (relative) luminosity change gains 1 mark only if no other marks awarded
   ignore correct or incorrect stages given beyond white dwarf

(15) [2]

(a) (i) Universe began at a (very) small (initial) point
      'it' refers to Universe

      'explosion' sent matter outwards
      or
      'explosion' causing Universe to expand
      accept gas / dust for matter
      accept rapid expansion for explosion

   (ii) light shows a red shift
        owtte
        the term red shift on its own does not score a mark

(16) [4]

(17) [4]
galaxies moving away (from the Earth)
‘it’ refers to light
‘they’ refers to galaxies
accept star for galaxy
do not accept planet for galaxy

(b) check reliability / validity of data
accept check data
accept collect more data

amend theory
or
discount the data
accept replace old theory with new theory

(c) answer involves (religious) belief
or
no / insufficient evidence
accept it cannot be tested

(a) gravitational force(s) (1)
accept ‘gravity’
balanced by (force(s) due to) radiation pressure (1)
accept equal

(b) by (nuclear) fusion (1)
of hydrogen to helium (other light elements) (1)
allow ‘low density’ for light
accept hydrogen nuclei / atoms form helium
response must clearly link one element(s) producing others
fusion to produce helium (2)

heavy element / elements heavier than iron are only produced (by fusion) in a supernova (1)
allow dense for heavy
ignore any reference to elements undergoing radioactive decay (to form other elements)
(a) wavelength (of light appears to) increase
   accept frequency (appears to) decrease
   accept light moves to the red end of the spectrum
   do not accept it moves to the red end of the spectrum
   do not accept light becomes redder

(b) (i) M is closer (to the Earth) than N
        M is moving (away from the Earth) slower than N

(ii) 520
      an answer between 510 and 530 inclusive gains 1 mark

(iii) more recent
      no mark for this but must be given to gain reason mark
      data more reliable
      accept data is more accurate
      or
      improved equipment / techniques
      more technology is insufficient
      or
      data obtained from more (distant) galaxies
      accept a wider range of data
      accept data closer to the line of best fit
      or data less scattered
      accept no anomalous result(s)
      accept all data fits the pattern

(c) wavelength is decreased
    frequency is increased

(a) (enough) dust and gas (from space)
    accept nebula for dust and gas
    accept hydrogen for gas
    mention of air negates this mark
pulled together by:

- gravitational attraction
  or
- gravitational forces
  or
- gravity

1

(b) forces (in the star) are balanced

  accept equal and opposite for balanced
  accept in equilibrium for balanced

forces identified as gravity and radiation pressure

  both forces are required
  gravitational forces inwards balance / equal radiation pressure outwards for 2 marks
  accept for 2 marks an answer in terms of sufficient hydrogen to keep the fusion reactions going
  accept for 1 mark an answer in terms of sufficient fuel to keep the fusion reactions going

1

(c) (explodes as) a supernova

1

any one from:

- outer layer(s) thrown into space
  do not accept just ‘thrown into space’

- scatters dust and gas into space (for the formation of new stars)
  do not accept just ‘dust and gas’

- elements distributed throughout space
  do not accept just ‘distributed’

- matter left behind / core may form a neutron star
  do not accept just ‘neutron star’

- a black hole will form if the gravitational forces are enormous / sufficient mass is left behind
  do not accept just ‘black hole’
  do not accept any references to ‘dark bodies’ or ‘black dwarfs’
  black hole forms if star is large enough is insufficient

1
(a) fusion (1)
    of hydrogen/H (atoms) (1)
    do not credit any response which looks like ‘fission’ or the word ‘fussion’
    credit only if a nuclear reaction

(b) fusion of other/lighter atoms/elements (1)
    reference to big bang nullifies both marks
    during super nova/explosion of star(s) (1)

(c) explosion of star(s)/super nova (1)
    reference to big bang nullifies both marks reference to the star running out of energy/material nullifies both marks
    at the end of the ‘life’ of star(s) / when they ‘die’ (1)